Southwest FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Meeting Held to Discuss Preliminary Results of the 1990-91 AMLR Field Season

Drs. Rennie Holt and Roger Hewitt, of the Antarctic Ecosystem Research Group (AERG), met in late May with principal investigators of the U.S. Antarctic Marine Living Resources (AMLR) program to discuss results and tentative conclusions from the 1990-91 field season in the Antarctic Peninsula area. As in past seasons, the field research consisted of two components: 1) land-based studies at Seal Island, a small island at the tip of the peninsula, and at Palmer Station, a U.S. scientific station further south on the peninsula; and 2) a research cruise aboard the NOAA Ship *Surveyor* in the waters surrounding Elephant Island, also at the tip of the peninsula.

Land-based research conducted by the field team at Seal Island included studies on growth and condition of Antarctic fur seal pups, foraging behavior of adult female fur seals, and other directed research on fur seals and all other pinnipeds on the island. Seabird research consisted of intensive studies of the reproductive and foraging behaviors of chinstrap and macaroni penguins, as well as reproductive studies of cape petrels. In addition, shipboard tracking studies of krill (*Euphausia superba*) predators were conducted.

Early in the season, fur seal foraging trips were relatively long in duration, possibly indicating that food was more difficult to obtain. However, the average foraging trip duration obtained over the entire season and the pup growth rates were not very different from those observed in previous seasons. The number of chinstrap and macaroni penguins occupying nests on Seal Island was down 20%, compared to last year. However, the chick growth rate and reproductive success of birds that did nest were equal to or higher than previous years. Shipboard predator tracking studies indicated that both fur seals and penguins foraged further offshore early in the season and close to shore late in the season. Preliminary analyses of prey (krill) abundance data from acoustic and net sampling suggests a good correlation between prey abundance and the foraging patterns of predators.

Research on aspects of the ecology of Adelie penguins was conducted at Palmer Station; this work was jointly funded by the National Science Foundation and the AMLR program. Chick counts at designated AMLR colonies decreased by 17%, compared to last season. As in past seasons, krill were the main component of the Adelie diet; however, the predominant krill size class was significantly larger than last season.

Hydroacoustic surveys conducted during Leg I of the *Surveyor* cruise showed krill were sparsely but widely distributed, with highest densities encountered nearshore north and south of King George Island, approximately 30 miles northeast of Elephant Island over deep water, and along the shelf/slope break north of Elephant Island. Krill biomass over the entire survey area during Leg I was estimated to be 2.7 million tons.

During Leg II, areas of highest krill densities were similar to Leg I, except very few krill were encountered around King George Island. The estimated krill biomass over the entire survey area was similar to Leg I; however, the portion in the Elephant Island area increased by approximately 50%.

Direct sampling for krill was accomplished aboard the *Surveyor* utilizing bongo net tows, Isaacs-Kidd-midwater-trawls (IKMT), and the multiple-opening-closing-environmental-sampling-system (MOCNESS). During Leg I, reproductively mature krill dominated catches north of King George and Elephant Islands; mixed adult and juvenile catches were obtained in Bransfield Strait south of the islands and near shore north of Elephant Island. Mature male and female krill showed a degree of horizontal separation, with males being more abundant to the northwest of Elephant Island and females being predominate to the northeast. The mean length of mature individuals (44 mm) was larger than that observed in January 1990 (43 mm), and in January-February 1988 (41 mm); noticeably absent in the catches were immature individuals in the 30-40 mm size range.

As on Leg I, reproductively mature krill dominated the catches during Leg II north of Elephant Island. However, mean size (46 mm) was 2 mm larger than on Leg I. Mixed catches of juvenile, immature and mature stages were taken only nearshore and between Elephant and King George Islands. In contrast to Leg I, immature stages were more abundant than juveniles, and

fewer females had developing ovaries or were gravid. Gravid females were taken late in the reproductive season (March 12) northeast of Elephant Island. In a larger context, relatively few juveniles and immature stages were collected during the 1990 and the 1991 surveys.

During Leg I, phytoplankton biomass, as indicated by chlorophyll-a concentrations (integrated to 100 m depth), ranged from 20 to 137 mg chl-a/m^2, with highest values northwest of Elephant Island and south of Clarence Island. Phytoplankton biomass was vertically stratified offshore from the shelf/slope break north of Elephant Island and deeply mixed on the shelf close to the island.

Chlorophyll-a concentrations were higher throughout the study area on Leg II. High phytoplankton biomass was observed northwest of Elephant Island, displaced slightly to the west from Leg I, and was primarily composed of small (<20 μm) cells. Larger cells composed high concentrations of phytoplankton biomass located south of Elephant Island and north of King George Island.

A hydrographic front was delineated north of Elephant Island running parallel to the shelf/slope break, where low salinity, well stratified Bellingshausen Sea water abutted vertically mixed Bransfield Strait water; this front persisted throughout both legs of the cruise. Strong westerly airflow, associated with high pressure over the southeast Pacific Ocean and low pressure systems over the Antarctic Peninsula, prevailed throughout most of the study period. (J. Rosenberg, FTS 893-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Ozone Depletion, UV Radiation, and Larval Fish Mortality

John Hunter and Russ Vetter of the SWFSC and Raymond Smith of the University of California, Santa Barbara, have received funding for a project to study the effects of increased ultraviolet radiation (UVB) on larval fish mortality. The project is part of the NOAA Climate and Global Change Program. The amount of UVB irradiation reaching the ocean's surface is increasing due to ozone depletion in the upper atmosphere, and the effects of increased UVB irradiation on sensitive life forms such as the unpigmented yolk-sack larvae of the northern anchovy are not known. The study is divided into three parts.

The first part of the study is to develop an assay for the amount of DNA damage caused by different doses of UVB and to follow the daily cycle of damage and repair caused by UVB in natural solar radiation. The second is an intensive field study that will employ a spectroradiometer mounted on a remotely operated vehicle (ROV). The ROV will measure the complete spectral irradiance, including UVB, that reaches different depths in the top 50 m of the water column where anchovy larvae occur. On the same cruises, stratified sampling of anchovy larvae at different depths in the water column will be carried out to determine the proportion of the total larval population that is subject to UVB damage. The amount of DNA damage found in natural populations will also be measured. The third part of the study is to combine the dose-effect data, natural spectral irradiance measurements, and larval distribution patterns into a model that can predict the mortality associated with different increases in UVB.

Previous studies conducted at SWFSC have shown that present-day UVB doses can cause high larval mortality in the top 10 cm of the water column. The present study is designed to actually measure UVB damage in field samples, evaluate the effects of different projected increases in UVB, and to examine the effects of UVB mortality in the context of the full distribution of anchovy larvae throughout the water column and within the context of other sources of larval mortality. (R. Vetter, FTS 893-7125)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Status of California Coastal Pelagic Fisheries in 1990

Cynthia Thomson, Terri Dickerson (CDF&G), Greg Walls (CDF&G), and Jim Morgan (SWR) have completed a report entitled "Status of the coastal pelagic fisheries in 1990" (Administrative Report LJ-91-22). The report describes management

Table 1. California commercial landings (metric tons) and ex-vessel value ($1,000's) of coastal pelagic species, 1982-1990 and 1985-1989 average.

Landings (metric tons)

Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1982	42,050	52,983	2,325	16,285	132	113,775
1983	4,300	50,682	3,404	1,816	352	60,554
1984	2,905	52,709	2,802	564	238	59,218
1985	2,009	43,090	2,367	10,275	592	58,333
1986	1,548	52,878	240	21,280	1,188	77,134
1987	1,303	53,475	5,048	19,984	2,095	81,905
1988	1,468	50,188	3,938	37,231	3,785	96,610
1989	2,449	55,924	1,092	40,877	3,907	104,249
1990	3,208	42,081	4,344	28,443	2,921	80,997
1985-89 Average	1,755	51,111	2,537	25,929	2,313	83,649

Ex-vessel revenues ($1,000's)

Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1982	2,124	10,480	1,087	3,604	26	17,321
1983	394	9,633	1,373	754	67	12,220
1984	665	9,531	832	305	43	11,376
1985	417	7,983	504	3,719	110	12,733
1986	274	8,590	83	4,882	215	14,044
1987	239	8,090	2,401	4,103	315	15,148
1988	367	8,082	1,695	8,067	582	18,793
1989	465	8,333	476	7,002	607	16,883
1990	603	5,608	1,935	4,683	346	13,175
1985-89 Average	352	8,215	1,032	5,555	366	15,520

Ex-vessel revenues corrected for inflation ($1,000's)[4]

Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1982	2,124	10,480	1,087	3,604	26	17,321
1983	379	9,277	1,322	726	64	11,768
1984	617	8,847	772	283	39	10,558
1985	375	7,181	453	3,345	99	11,453
1986	239	7,502	72	4,264	188	12,265
1987	203	6,885	2,043	3,486	268	12,885
1988	302	6,641	1,393	6,629	478	15,443
1989	364	6,515	372	5,475	475	13,201
1990	459	4,265	1,471	3,561	263	10,019
1985-89 Average	297	6,945	867	4,640	302	13,049

[1]Includes both reduction and non-reduction landings, but not live bait catch.

[2]Sardine landed incidentally with mackerel is not included in these figures.

[3]The 1982-1985 figures pertain to sardine landed incidentally with mackerel. The State of California lifted its moratorium on sardines in 1986 so the 1986-1990 figures include both incidental and directed harvests (other than live bait).

[4]Deflated by GNP Implicit Price Deflator (base year=1982).

regulations, the commercial harvesting and processing sectors, and recreational fisheries as they relate to the coastal pelagic species.

The species composition of statewide coastal pelagic landings and revenues from 1982 to 1990 are presented in Table 1. Statewide landings in 1990 totalled 80,997 metric tons (t) and had a nominal ex-vessel value of $13.2 million. Total landings were 22% lower than 1989 and 3% lower than the 1985-1989 average, largely because of the decline in mackerel and squid harvests. Ex-vessel revenues (corrected for inflation) were 24% lower than the 1989 value and 23% lower than the 1985-1989 average. The decreased availability of mackerel during 1990 may have been due to unusually warm water temperatures that displaced mackerel farther to the north, particularly during the first half of the year. Sardine landings attributable to the directed and dead bait fisheries changed modestly from 1989 to 1990, but incidental take declined, resulting in a 25% overall decline in sardine landings.

Whereas 47% of total coastal pelagic landings consisted of mackerel in 1982, mackerel accounted for over 80% of total landings in 1983-1984 due to the precipitous decline in anchovy and squid landings. Although anchovy landings have remained low, squid landings rebounded in 1984 and reached a record high of 40,877 t in 1989. Mackerel has accounted for over one-half and squid for approximately one-third of total landings during 1988-1990.

Live bait harvests, which are not reflected in Table 1, included 540 t of sardine and 4,842 t of anchovy in 1990. These figures are based on logbook information provided by bait haulers and may underestimate the true harvest because of delinquent logs.

The Pacific Fishery Management Council (PFMC) has taken action to place Pacific mackerel and Pacific sardine (which are currently subject to quota management by the state of California) and jack mackerel (which is currently not regulated) under federal regulatory jurisdiction. These changes will take the form of an amendment to the Northern Anchovy Fishery Management Plan, which will be renamed the Coastal Pelagics Fishery Management Plan. Enactment of the federal regulations will occur in 1993 at the earliest. (C. Thomson, FTS 893-7116)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

BIOLOGY ASSESSMENT PROGRAM

Age at Sexual Maturity Examined as a Possible Compensatory Mechanism for Offshore Spotted Dolphins

Potential biological indicators of population status are being investigated by the Biological Assessment Program. Compensatory responses in the life history of the dolphin species exploited, and thereby reduced in abundance, by the yellowfin tuna purse-seine fishery were predicted to have occurred. Specifically, the age at attainment of sexual maturity (ASM) has been found to be negatively correlated with population abundance in some dolphin and whale populations, and a study to analyze ASM as a possible index to population condition for the spotted dolphin, *Stenella attenuata*, was conducted. Two stocks of the offshore spotted dolphin, northern and southern, were selected for comparison as they have been subjected to different rates of exploitation; the northern stock has been the most severely exploited and reduced in abundance. Consequently, an earlier ASM was predicted for the northern stock, relative to the southern stock while a decreasing trend was expected for each stock between 1974 and 1988, if population abundance were found to be declining. Additionally, the slope of a trend in ASM should be "steeper" for the northern stock as compared to the southern stock.

Life history specimens with both teeth and reproductive data available were randomly selected for preparation of teeth for aging from the available samples of female spotted dolphins. The targeted sample size was 50 dolphins per year for the years 1974-1988; a sample size determined to be sufficient to produce annual estimates of ASM and detect a decreasing trend in ASM of 1.5 years. When less than 50 animals were available during a year, those available were sampled. The total sample size was 971 specimens (564 specimens from the northern stock and 407 specimens from the southern stock).

No significant trend in ASM over the study period, 1974-1988, was detected for the northern stock of the offshore spotted dolphin. For the

southern stock, trends were not determined, as only 3 years of data were available for annual estimates of ASM (Figure 1). All data were pooled over years, and the ASMs for the two stocks were compared with a t-test. The pooled estimates of ASM were 11.12 years (SE=0.2289) and 9.78 years (SE=0.2645) for the northern and southern stocks, respectively; these estimates were statistically significantly different ($p<0.001$); however, we had expected the ASM to be lower in the northern stock.

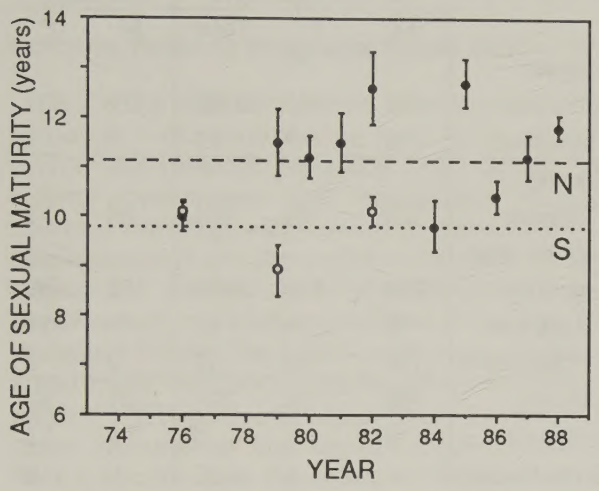

Figure 1. The annual estimates of ASM are plotted here for each stock: northern (filled circles) and southern (open triangles). Error bars indicate ±1 SE. The linear regression fit to the northern stock estimates was not drawn because the slope was not significantly different from 0. The dashed lines indicate the pooled estimate of ASM for the northern stock (N) and for the southern stock (S).

The corresponding reproductive data were also analyzed. The youngest mature female was 7 years and the oldest immature female was 16 years for the northern stock. Similarly, the range of ages over which sexual maturity occurred was from 6 years to 11 years, for the southern stock. No significant differences between the stocks were detected in the fraction of mature females in the sample, or the fraction of mature females that were pregnant, lactating or simultaneously pregnant and lactating. The pregnancy rates for each stock were 0.27 for the northern stock and 0.34 for the southern stock, and while these rates were not statistically significant, the direction was opposite to what we had predicted, as in the ASM analysis. A higher pregnancy rate had been expected for the northern stock relative to the southern stock.

Collectively, these life history parameters for the northern stock (high ASM and possibly low pregnancy rate) imply a low reproductive rate, relative to the southern stock. Therefore, our results do not support the original hypothesis of a model of population compensatory responses correlated with population abundance.

The contrary results of this study lead us to suggest alternate models. There may be inherent differences between the northern and southern stocks of spotted dolphin due to genetic divergence between the stocks. Morphologically the two stocks are recognized as distinct. The animals from the northern stock are, on average, 2.5 cm longer in length at attainment of sexual maturity and asymptotic length. The breeding seasons are also different for these two stocks. In the north the breeding season is diffuse throughout the year with a peak occurring in the spring: March to June and a second peak in the fall: September to November whereas there is a relatively distinct peak in the spring (March to June) for the southern stock with few births noted during the rest of the year. These patterns of reproductive seasonality may be due to the different oceanographic environments: the north being more constant and the south more variable. Although there is evidence for movement of animals from south to north-west, the differences in reproductive seasons and ASM are consistent with the morphological data suggesting that the northern and southern stocks of spotted dolphins are distinct.

Other possible explanations as to why the results of this study were not as predicted and a model of compensatory mechanism inappropriate, include (1) a change in carrying capacity, (2) a change in physiological processes (i.e., physiological "stress" caused by the fishery) and (3) no change in ASM over the population densities observed. On the other hand, the model of compensatory responses resulting from a decline in abundance may be appropriate but has not been identified because the available sample sizes are too few in number, the available data are biased, or there is an unaccounted for time lag in response. (S. Chivers, FTS 893-7093)

1990 Incidental Kill of Small Cetaceans in Eastern Tropical Pacific Documented

The incidental kill of small cetaceans for 1990 was summarized and submitted to the International Whaling Commission's annual meeting in May 1991, by Kelly Peltier, Ruth Miller, and Susan Chivers of the Biological Assessment Program. Observers placed aboard yellowfin tuna purse-seiners

recorded information about fishing activities as well as geographic location, species, and number of animals killed. Produced annually, this report summarizes the observed kill by U.S.-registered vessels by 5°-square area, species, stock, and sex. Additionally, life history data were collected from individual dead animals. The life history data were further summarized for the report by sex, total specimen length and, for females, by reproductive condition.

One hundred and seven trips were made by U.S.-registered vessels with biological technicians on board in 1990; 69 of these trips reported dolphin kills. Observers were placed aboard all U.S.-registered vessels fishing during 1990; the second year in a 3-year program to observe all fishing trips. The observed incidental kill of 5,083 small cetaceans was composed of 3,195 spotted, 1,576 spinner, 231 common, 8 bottlenose, 26 rough-toothed, and 47 unidentified dolphins. For spotted and spinner dolphins, the observed kill and life history data were also stratified by stock.

The geographic distribution of purse-seine sets with observed kill is illustrated in Figure 2. Life history data were collected from pantropical spotted, spinner, common, and bottlenose dolphins on 40 of the 69 trips with kill reported. Total body length was recorded for 726 females and 616 males, and reproductive data were available for 442 females (Table 1).

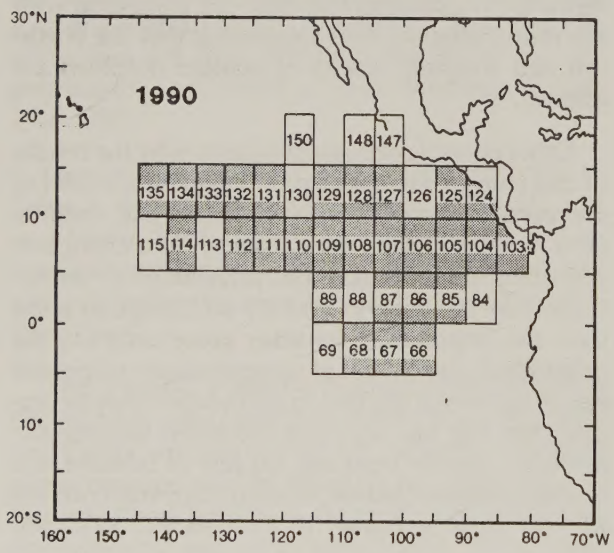

Figure 2. Geographic distribution of the observed incidental kill of small cetaceans during 1990 for 112 trips by U.S.-registered vessels. The data are summarized by 5°-square areas. The numbered blocks without shading are regions where only a tally of the observed kill was collected; stippled blocks indicate areas where both tally and life history data were collected.

Table 1. Total observed kill and the number of specimens collected for life history data by species, stock, and sex (M=male, F=female). Each species or stock total in the observed kill column includes dolphins of unknown sex.

Species	Observed kill			Life history data collected	
	M	F	Total	M	F
Spotted:					
Northern	690	842	3169	372	437
Southern	10	7	26	8	4
Spinner:					
Eastern	70	84	304	54	59
Whitebelly:					
Northern	256	319	1168	132	169
Southern	16	15	57	16	15
Unidentified	15	26	47	2	2
Common	45	50	231	31	37
Bottlenose	2	4	8	1	3
Rough-toothed	4	1	26	0	0
Unidentified	0	0	47	0	0
Total	1108	1348	5083	616	726

The observed incidental kill of small cetaceans for 1990 (5,083) by U.S.-registered vessels was greatly reduced from the observed incidental kill of 1989 (12,548). The decline was primarily due to the U.S. tuna canneries' policy, initiated in June 1990, of not buying tuna caught in conjunction with dolphins. This policy caused a decrease in the incidental take of small cetaceans in the ETP by U.S.-registered vessels. In 1990, only 64% of all observed trips reported kills, while in 1989, 88% reported kills. However, because of the U.S. tuna canneries' policy, there was also a reduction in the number of U.S. purse-seine vessels fishing in the ETP. In the first quarter of 1990, the U.S.-registered purse-seine fleet consisted of 31 vessels. By the end of the last quarter of 1990, the U.S.-registered purse-seine fleet was reduced to 17 vessels and most of these were not fishing on dolphins.

The life history data collected for 1990 represents 26% of the observed total kill. This is the third year of increase and compares to 18% in 1988 and 24% in 1989. The fraction of the kill collected for life history

data complete with reproductive information is 8% for both males and females, which is slightly higher than the previous 2 years at 7%. The increase in the collection rate is most likely the result of a smaller total kill. (S. Chivers, FTS 893-7093)

HONOLULU LABORATORY

Honolulu, Hawaii

MFCMA-Related Programs Reviewed

A panel of external fisheries scientists met at the Honolulu Laboratory during June 10-15, 1991, to review the research programs that support the fishery conservation and management requirements of the Magnuson Fishery Conservation and Management Act in the central and western Pacific (Figure 1). During the review, Director George Boehlert and task leaders of several of the research programs briefed the panel on the organizational structure of the Laboratory, its program relationships to NMFS goals and objectives, and its ties with other laboratories and organizations; discussed data collection and the status of the fisheries in Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands; and provided background information on fishery dynamics, stock assessment, and research supporting management of crustaceans, bottomfish and seamount groundfish, precious corals, non-scombrid pelagic fishes, and tuna.

Figure 1. Participants and panel members (P) of the MFCMA-related program review of the Honolulu Laboratory, June 10-15, 1991 (left to right): E. C. Fullerton, Richard Neal, Rick Methot (P), Dave Mackett, Ray Hilborn (P), Izadore Barrett, George Boehlert, Robert Francis (P), and Jon Sutinen (P). Panel member not shown is Michael Sissenwine.

A perspective of the fishery data and monitoring needs of the Western Pacific Regional Fishery Management Council (WPRFMC) was provided by William Paty, chair of the WPRFMC and the State of Hawaii Board of Land and Natural Resources, and Bunny Lowman, staff economist for the WPRFMC.

Panel members included Robert Francis, the panel's chair and Director of the University of Washington's Fisheries Research Institute; Raymond Hilborn, University of Washington; Rick Methot, Alaska Fisheries Science Center; Michael Sissenwine, Senior Scientist, National Marine Fisheries Service; and Jon Sutinen, University of Rhode Island. Participants in the review included Paty and Lowman as well as E. C. Fullerton, Director of the Southwest Region (SWR); Izadore Barrett, Science and Research Director, SWR; Richard A. Neal, Deputy Director, SWFSC; and David J. Mackett, Planning Officer of the SWR.

The review panel reported its preliminary findings to Fullerton and Barrett and presented a formal, written report in July. (G. Boehlert (808) 943-1221)

PELAGIC RESOURCES INVESTIGATION

Catch Rates of Hawaii's Troll and Handline Fisheries Examined for Evidence of Interaction with Domestic Longline Fishery

Recently, Fishery Biologist Christofer Boggs completed a preliminary study examining data from Hawaii's troll and handline fisheries for evidence of interaction with the domestic longline fishery. The study was initiated because of concern that longline catches might have become great enough to impact the local abundance of fish.

Annual (1983-89) and monthly (January 1987 to June 1990) summaries of catch and number of trips in Hawaii's commercial troll and handline fisheries, provided by the Hawaii Division of Aquatic Resources (HDAR), were used to examine catch per trip over time in these two fisheries. The data were also deseasonalized so that 1990 data could be compared with earlier years. Catch per trip may not be a good measure of catch per unit

effort (CPUE) because changes undoubtedly have occurred in the fishing methods and in reporting over the years; however, this is the only catch rate index that can be calculated from HDAR data. To see whether there was any evidence of fishery interaction, troll and handline catches per trip were also examined in relation to Hawaii's longline catches as given by the National Marine Fisheries Service (NMFS) market monitoring data from January 1987 to June 1990. This analysis was broken down by season to remove a potential source of bias.

The most interesting results were the yellowfin tuna, *Thunnus albacares*, catch rates which gave the appearance of declining with increasing longline catch (Figure 2). However, this decline could well be due to other factors. Whatever the causes, the decline in yellowfin tuna catch per trip over the last few years was real, being reflected in the data from many gear types. However, the decline did not result in troll or handline catch rates substantially lower than in 1983, before the longline expansion. Also important was the absence of any clear relationships between longline catch and catch rates for blue marlin, *Makaira mazara*; striped marlin, *Tetrapturus audax*; mahimahi, *Coryphaena hippurus*; ono (wahoo), *Acanthocybium solandri*; bigeye tuna, *Thunnus obesus*; and swordfish, *Xiphias gladius*. Because the most recent data available for the present study were from June 1990 and Hawaii's domestic longline fishery has doubled in size since then, the potential for fishery interaction may now be greater than during the study period (1983-June 1990).

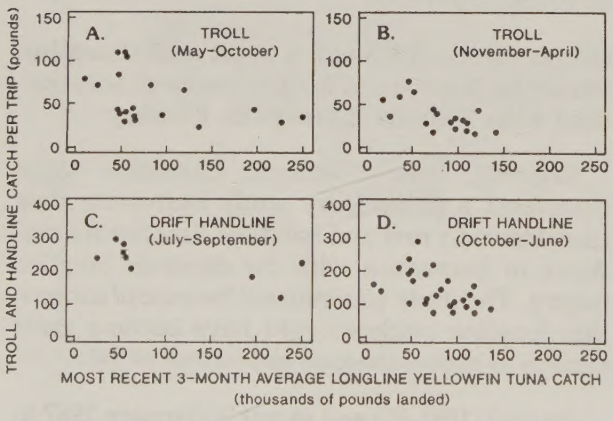

Figure 2. Catch of yellowfin tuna on a monthly per-trip basis by troll and drift handline gear versus the most recent 3-month average catch by longline gear in Hawaii during January 1987 to June 1990. Troll and handline data are from the Hawaii Division of Aquatic Resources, and longline data are from the market monitoring program of the Honolulu Laboratory.

A review of the status of the small-vessel pelagic fisheries at a greater-than-annual resolution indicated that some overall declines may have occurred that were not apparent from the annual time series. The average annual catch per trip values for 1988-89 compared with the 1983-85 average indicated that, in 1988-89, troll catch rates were higher for both marlin species but were lower for yellowfin tuna, mahimahi, and ono; handline catch rates were lower for all species except bigeye tuna. However, these changes were small compared to changes seen over a longer time period (1962-89). Within the limited range of Hawaii's pelagic fisheries, CPUE is characterized by wide fluctuations that are due to many factors; some of these fluctuations may obscure or mimic fishery interaction. A more thorough approach, one that addresses the major problems with the available fisheries data and considers biological, environmental, and economic factors, is still needed. Further study using logbook data collected over the next 3 years will be necessary to reliably assess the possible impacts of the longline fleet expansion.

Boggs' study has been reported in "A preliminary examination of catch rates in Hawaii's troll and handline fisheries over a period of domestic longline fishery expansion" (SWFSC Administrative Report H-91-05). (C. Boggs (808) 943-1222)

INSULAR RESOURCES INVESTIGATION

Stock Assessment of Pelagic Armorhead with Hook Timers

"Stock assessment using times to capture individual fish on longlines" was recently completed by David A. Somerton, leader of the Insular Stock Assessment Program, and Fishery Biologist Bert S. Kikkawa, and submitted for publication in *Fishery Bulletin*. In stock assessments that are based on the CPUE (*U*) of research longlines, longlines frequently experience saturation; therefore, longline *U* tends to increase asymptotically with fish density and is insensitive to changes when densities are high. For stock assessments of armorhead, *Pseudopentaceros wheeleri*, on the Southeast Hancock Seamount, the problem of gear saturation is particularly acute, because the population has been extremely overfished and will likely increase greatly in the future.

According to the paper by Somerton and Kikkawa, one solution to this problem could be achieved by expressing the index of relative abundance in terms of the rate at which baited hooks are

struck rather than the total number struck during a longline soak. One such index, the hazard rate or the specific loss rate of baited hooks (λ), can be estimated from capture times or from the time between the start of fishing and the strike of every fish caught. Like U, λ is assumed to be proportional to population density. A maximum likelihood estimator of λ can be derived by assuming that the capture time frequency distribution for armorhead conforms to a exponential probability model. When strikes by non-target species and gear retrieval are considered as censoring processes, the likelihood estimator is:

$$\lambda = \frac{n_1}{\sum_{i=1}^{n_1} t_{1,i} + \sum_{i=1}^{n_2} t_{2,i} + \sum_{i=1}^{n_3} t_{3,i}};$$

where n_1 and n_2 are the number of target and non-target fish that are caught, n_3 is the number of baited hooks retrieved, and $t_{1,i}$, $t_{2,i}$, and $t_{3,i}$ are the ith capture times for target and non-target fish and the ith soak time for baited hooks. Capture and soak times were obtained by using hook timers or small timing devices attached to the hooks and activated when a hook is struck.

Comparison of U and λ over the four stock assessment cruises (1987-90) using hook timers suggests that U increases with λ at a diminishing rate, although the recent changes in U and λ are so small that the effect is not pronounced (Figure 3). The theoretical relationship between U and λ indicates that a further doubling or tripling of population size would severely diminish the responsiveness of U to changes in population density (Figure 3). This indicates hook timers should be required on future stock assessment cruises to accurately track increases in armorhead population size. (D. Somerton (808) 943-1259)

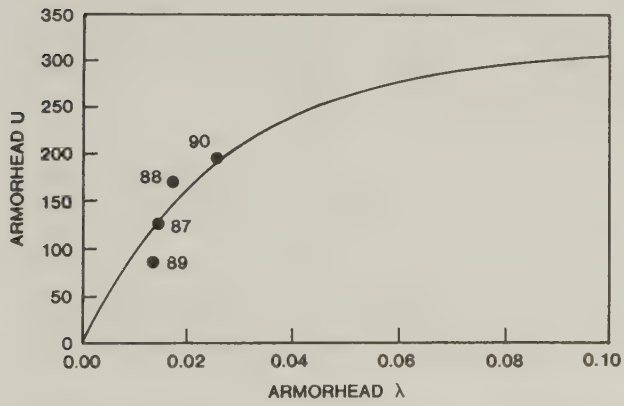

Figure 3. Armorhead CPUE (number per 1,000 hooks) and armorhead λ (average of the regression and maximum likelihood estimates with proportional allocation) for each stock assessment cruise, 1987-90. In addition, the theoretical variation in U (CPUE) as a function of λ (solid line) is shown for a range of λ values possible for the Southeast Hancock Seamount.

FISHERY MANAGEMENT RESEARCH PROGRAM

SWFSC-SWR Economic Research Plan

A plan which identifies the major program areas, methodologies, and activities to guide the annual allocation of the joint SWFSC-SWR economics fund was completed in May, "Southwest Fisheries Science Center and Southwest Region economics research plan, 1990-95" (SWFSC Administrative Report H-91-07). Coauthors of the plan are Industry Economist Samuel G. Pooley, with the Honolulu Laboratory; Samuel F. Herrick, Jr., Dale E. Squires, and Cynthia J. Thomson of the La Jolla Laboratory; and G. W. Silverthorne of the Southwest Region.

The plan identifies five major research priorities for the economics program: 1) fisheries management; 2) NMFS non-MFCMA interests such as habitat, trade and development, and marine mammals; 3) fishery institutions; 4) natural resource economic methods; and 5) fisheries economics data. It is primarily oriented toward the fishery management plans in the western Pacific region.

Some of the proposed program activities include sponsoring a conference on individual transferable quotas, creating bioeconomic optimization models for applications of control theory for the west coast groundfish fishery, understanding the economics of the pelagic gear interaction problem in Hawaii, and studying the tuna product cycle. (S. Pooley (808) 943-1216)

Hawaii's Longline Fishery Reported for Early 1991

In Hawaii's longline fishery during the first quarter of 1991 (January-March), 124 vessels made 542 trips, based on the first logbook data compiled in a quarterly report by the Fishery Management Research Program (FMRP) staff. Data processed from 523 of the trips revealed that 3,252 sets were made with more than 3.3 million hooks. Catches included 17,800 broadbill swordfish, *Xiphias gladius*; 15,400 bigeye tuna, *Thunnus obesus*; and 13,400 sharks. Only 10% of the sharks were kept compared with 94% of the billfish and 96% of the tunas. Catch

rates (number of fish per 1,000 hooks) equaled 8.8 for billfish, 6.8 for tuna, and 7.2 for other pelagic fishes.

Most of the sets were made within the main Hawaiian Islands (MHI) exclusive economic zone (EEZ, 60%); 13% were made in the Northwestern Hawaiian Islands (NWHI) EEZ, and 27% outside the U.S. EEZ. Broadbill swordfish catch rates were highest outside the U.S. EEZ, whereas bigeye tuna catch rates were highest in the MHI EEZ.

Reports on the longline fishery will be issued on a quarterly basis, 45 days following the close of the quarter.

As part of the FMRP's monitoring of the Hawaii longline fishery, computer programming of a longline logbook inventory system was recently completed by Stacey S. Yoshimoto, operations research analyst. The inventory will allow more accurate collection of logbooks on a timely basis, as well as provide a data base for analyzing fleet activity. To improve the data quality from the longline logbook program and increase the coverage of shoreside MHI landings, FMRP personnel visited the islands of Hawaii and Kauai in June, and will visit Maui and Molokai later, to identify the longline fishing vessels off-loading in those ports, and the major buyers of longline, bottomfish, and small-boat pelagic fishes. In addition, new laminated species identification cards are being given to all longline vessel captains to increase logbook accuracy. The cards are available with annotations in three languages: English, Korean, and Vietnamese. (S. Pooley (808) 943-1216)

Western Pacific Regional Fishery Management Council (WPRFMC) Holds Meeting on Proposed Longline Regulations

The WPRFMC held a public hearing May 13 on proposed regulations pertaining to longline fishing around Hawaii. About 150-250 people attended the hearing; most were small-boat fishermen from Waianae and Haleiwa on Oahu. The vast majority of the participants opposed any liberalization in proposed restrictions on longline vessel activity in Hawaii.

Industry Economist Samuel G. Pooley, with the Honolulu Laboratory, summarized NMFS research on the interrelationship of longline landings, troll-handline catch rates, and market prices. Few statistically significant relationships have been identified because of limitations in the data and time available to conduct the analysis. However, research using disaggregated data will continue in order to better understand the extent, if any, of these interactions. This presentation was based on two research reports prepared by the FMRP for the WPRFMC.

One of the reports, "Hawaii pelagic fishery catch and effort: 1990 results," was on the FMRP's Hawaii market monitoring data designed to identify trends in catch per trip by small-scale troll and handline vessels in Hawaii. The report was complied by Pooley and Stacey S. Yoshimoto, operations research analyst. The report will by used by the WPRFMC in preparing amendments to the fishery management plan for pelagic species.

According to the report, there is a strong correlation between data collected from trollers and handliners based on Oahu and earlier work by Fishery Biologist Christofer Boggs, with the Pelagic Resources Investigation, who used data collected by the State of Hawaii on the commercial landings of trollers. The report by Pooley and Yoshimoto provides 10 plots of catch per trip time trends and relationships with longline landings for 1987-90.

The second report prepared for the WPRFMC by Pooley was entitled "Revised market analysis: Hawaii yellowfin tuna." This report examines the relationship between yellowfin tuna prices and longline landings. Pooley found that there were no trends in average monthly yellowfin tuna prices from 1987 to 1990 for Oahu-based or outer-island-based trollers and handliners, or for longline fishing vessels. A strong seasonal peak in prices was identified, based on the peak market season of December-April.

Neither of these reports provided strong support for the WPRFMC's proposed regulation of the longline fleet, but additional research is required to identify these interrelationships. At the subsequent WPRFMC meeting, the proposed moratorium on new entry into Hawaii's longline fishery was approved. (S. Pooley (808) 943-1216)

Hawaii's Commercial Fishery in 1990

The Fishery Management Research Program (FMRP) is responsible for monitoring Hawaii's commercial fishery through a variety of logbook and shoreside monitoring programs. Estimates of total commercial landings in Hawaii for 1990 are as follows:

Type of fishery	Pounds landed	Value (in millions US$)
Longline	13,100,000	28.8
NWHI bottomfish	420,000	1.1
MHI bottomfish	830,000	3.3
MHI pelagics[1]	4,500,000	7.0
Aku boat[2]	1,000,000	1.8
NWHI lobster	949,000	4.9
Other	1,700,000	3.5
Total	22,500,000	50.4

[1]MHI pelagics = billfish, sharks, mahimahi, ono (wahoo), and tuna landings by troll and handline vessels.

[2]Aku boat = pole-and-line skipjack tuna fleet.

Total landings in 1990 were the same as in 1989, although revenue was up 2% (less than the rate of inflation). The tremendous growth in the longline fleet over the past 3 years led to rapidly increased landings by that fleet; landings in 1990 were 35% higher than in 1989. Landings of MHI pelagic species fell marginally (7%). Both fisheries had increased landings of yellowfin tuna. The aku boat fleet had a particularly bad year, with landings down by 65%. The MHI bottomfish fishery also had a substantial decline (down 30%). The Insular and Pelagic Resources Investigations are evaluating these trends; their analyses will be used by the WPRFMC plan monitoring teams.

The FMRP also revised its estimates of 1989 landings, slightly increasing the total landings to 22.5 million ($47.2 million). The revision was based on a new estimation procedure for dealing with MHI landings of pelagic species. The new procedure incorporates annual information from neighbor-island locations (i.e., Hawaiian Islands other than Oahu) directly into the estimation procedure. (S. Pooley (808) 943-1216)

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Hawaiian Monk Seals Born on Oahu and Kauai

Hawaiian monk seals, *Monachus schaunislandi*, live and breed almost exclusively in the remote NWHI extending approximately 1,600 km from the island of Nihoa to Kure Atoll. Seals are sometimes sighted in the main, inhabited islands, but births there are rare. Until this year, the only confirmed birth in the MHI occurred on Kauai in 1988. In spring 1991, two births were documented, one each on Oahu and Kauai.

A female pup was born on Oahu on March 15 at Waiale'e Beach, an isolated area on the north shore. Because of the presence of dogs in the area, as well as the possibility of disturbance to the mother and pup by curious onlookers, staff of the Marine Mammals and Endangered Species Program (MMESP) quickly cordoned off the area and established a 24-hour watch of the pair. This procedure proved particularly worthwhile during the first week after the birth, when heavy rains in the area flooded nearby Waiale'e Stream. At least once the pup was rescued from being swept to sea by the swollen stream which overwashed the beach. MMESP personnel were joined later by officers of the State of Hawaii Division of Conservation and Resource Enforcement, as well as by a cadre of volunteers which alternated in shifts to maintain the 24-hour vigil.

The pup nursed normally for 45 days and weaned from her mother on April 29. Because the reefs of Oahu's north shore are strewn with set nets which pose a significant hazard to a weaned pup learning to feed, MMESP personnel decided to capture and transport the pup to the Head Start Project at Kure Atoll. On April 29 she was measured, weighed, and taken to Sea Life Park to be screened for diseases. On June 12, the pup was flown by a U.S. Coast Guard C-130 to Kure Atoll, where she joined two yearlings and four weaned pups being held in the Head Start pen. She will learn to catch reef fish in the pen and will be released to the wild in September.

A second female pup was born at Haena Point on Kauai's north shore on April 26. Although the site is distant from the main road, it is nonetheless a popular fishing and windsurfing location, and prompt action was required to prevent inadvertent harassment of the mother and pup. Staff of the NMFS Southwest Region's Pacific Area Office met with personnel from the nearby U.S. Fish and Wildlife Service's Kilauea Point National Wildlife Refuge, who agreed to take the lead in coordinating volunteer groups to watch the seal. As with the pup born on Oahu, the area was cordoned off and a 24-hour vigil was maintained until the pup weaned on June 16. Staff of the MMESP measured and tagged the pup, which was not moved from the beach where she weaned. It is hoped that she will survive successfully around Kauai, as has the pup born there in 1988. (J. Henderson (808) 943-1225)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Long-Term Coastal Temperature Time Series Along the Western U.S.

Global climatic change is currently an area of serious concern to the public and of major research interest to scientists. Oceanic conditions are linked to large-scale environmental changes because of their close interconnection with the atmosphere. The ocean reflects physical trends in the atmosphere due to changes in the long-term wind field, cloud cover, precipitation, and the amount of ocean-atmosphere heat exchange. Along the North American west coast, such atmospheric variability affects coastal ocean conditions both directly, via fluctuations in local wind-driven flow, upwelling intensity and freshwater inflow, and indirectly, through variations in the California Current System.

Selected coastal time series, particularly sea level and temperature, are of sufficient length to display long-term environmental trends and allow possible anthropogenic effects to be examined. However variations in ocean parameters associated with long-term and global scale changes are masked by the shorter time-scale fluctuations of tides, weather systems, the annual cycle and even El Niño-Southern Oscillation (ENSO) events. To determine, quantify and predict climatic changes with confidence, long (decade to century) environmental time series must be studied, and the effects of shorter period phenomena accounted for and removed.

Researchers at PFEG are currently surveying lengthy atmospheric and oceanographic data sets to separate climatic and shorter period trends, and relate these changes to spatial and temporal patterns in fish recruitment and catch. A recent addition to this data base is several long records of daily sea surface temperature (SST), obtained from 19 west coast stations from Neah Bay, WA to La Jolla, CA (Table 1). Most records extend back to 1955. All go back more than 18 years; over 65 years of daily SST have been obtained at four sites. In addition, coastal salinity time series are available at seven of these stations.

Table 1. Coastal stations where long-term daily SST time series have been collected. Asterisk denotes daily salinity samples also obtained. Latitude of each station, and the start month and year of SST records are given. Date for La Jolla refers to SST series; 5-meter (bottom) temperature available since 7/26.

Coastal stations	Latitude	Start of series
Neah Bay, WA	48°22.1'N	01/55
Charleston, OR	43°20.7'N	05/66
Crescent City, CA	41°44.7'N	01/55
*Trinidad Beach, CA	41°03.3'N	01/73
*Bodega Bay, CA	38°19.9'N	01/57
*Farallon Is. CA	37°41.8'N	02/25
Santa Cruz, CA	36°57.5'N	02/55
Pacific Grove, CA	36°37.3'N	01/19
*Granite Canyon, CA	36°25.9'N	03/71
Morro Bay, CA	35°22.2'N	11/61
Port San Luis, CA	35°10.1'N	01/72
Santa Barbara, CA	34°24.2'N	01/55
Point Mugu, CA	34°06.0'N	01/67
Point Dume, CA	34°01.1'N	12/56
Santa Monica, CA	34°00.5'N	01/55
*Balboa, CA	33°36.0'N	11/24
San Clemente, CA	33°25.0'N	07/65
*La Jolla, CA	32°52.0'N	08/16

These time series were assembled by Maridale Orpilla and Douglas McLain (NOAA Center for Ocean Analysis and Prediction, Monterey), who periodically receive updates from Patricia Walker and John McGowan at Scripps Institution of Oceanography, La Jolla. Maridale has been working with Frank Schwing (PFEG), reformatting, editing and plotting the time series. She is now investigating statistical methods for filling in missing data, and analyzing and presenting the data in an informative manner.

One example of how these data can be presented is shown in Figure 1. Monthly averages of daily SST at 16 coastal sites were used to contour isotherms as a function of time and latitude for the period 1981-83. This figure demonstrates the typical spatial and interannual variability seen in the SST series, and includes the effects of the 1982-83 ENSO event. The annual signal is largest south of 35°N and north of 41°N. The strong influence of upwelling off central California is evidenced by the minimum annual

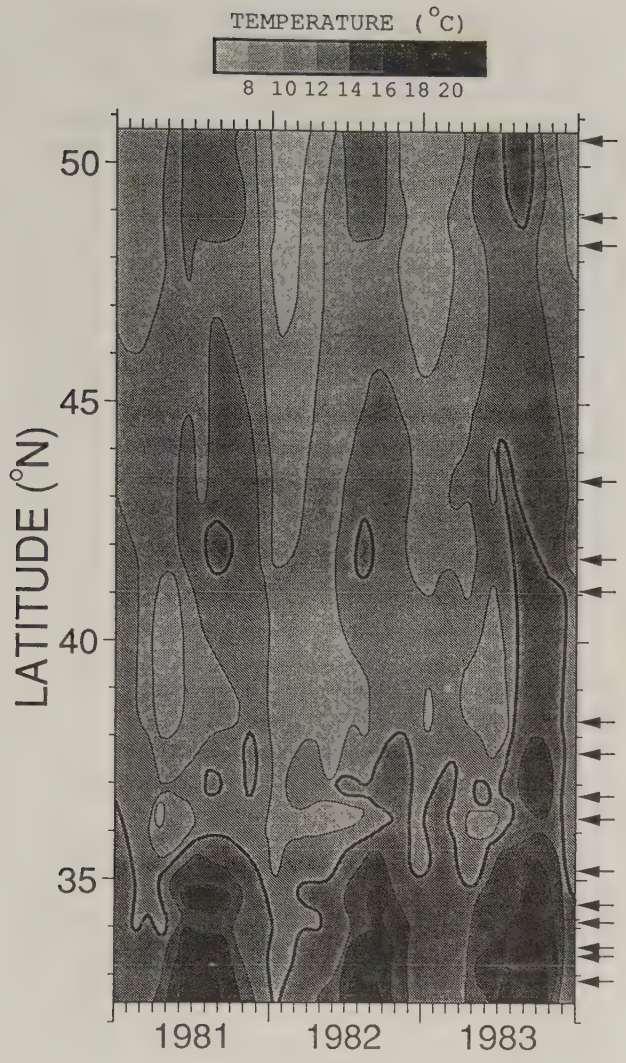

Figure 1. Contour plot of coastal temperature during 1981-1983 versus latitude, based on monthly mean SST at 16 selected stations along the western North American coast. Latitude of stations used is shown by arrows. Darker shading denotes warmer temperature. Contour interval 2°C; isotherm values range from 8 to 20°C. Bold contour denotes 14°C isotherm.

temperatures each spring. These results also show that SST is not necessarily coherent over large alongshelf extents. For example, Pacific Grove (36°37'N) lies in a protected and fairly shallow portion of Monterey Bay, and is less affected by upwelling than the more exposed stations to the immediate north and south. Santa Barbara (34°24'N) is also persistently warmer than adjacent locations.

The 1982-83 ENSO event is characterized by warmer than normal SST along the entire coast, beginning late 1982. ENSO effects are more evident north of Point Conception (34.5°N), probably due to the combined influence of reduced upwelling, an increase in the percentage of warmer offshore water near the coast, and an increase in the poleward transport of warmer water. The 14°C isotherm extended north to about 44°N in July 1983, and also appeared off Vancouver Island. In contrast, 14° water typically extends only to about 37°N. While the most dramatic interannual variation is associated with ENSO events, notable differences between 1981 and 1982 are also apparent. Winter 1982 SST was colder along the entire coast, while cooler water was seen during the 1981 upwelling season off Central California.

The PFEG staff is examining the time and space scales that control coastal ocean variability, using these daily long-term time series. The daily SST series provide finer alongshore spatial resolution than analogous data sets used in the past. An advantage of daily over monthly-averaged SST records, which have been available in the Pacific climate (PACLIM) data base for some time, is that synoptic events can be studied over long time periods and large spatial scales. These events, which lead to alternating periods of upwelling and relaxation, are believed to be closely linked to the distribution and recruitment success of many commercially important species of fish. Coastal SST series complement data collected during hydrographic surveys, and extend our view of temporal variability farther into the past. This allows us to examine a greater spectrum of historical environmental conditions, and increases our confidence in the patterns defined from limited ship observations. By studying such ephemeral variations in coastal systems, we will hopefully be able to describe and comprehend the true long-term changes occurring in the coastal environment and on global scales. (F. Schwing (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

1989-90 South Pacific Albacore Fisheries Data Summarized

Biological Technician Gary Rensink completed an Administrative Report (LJ-91-14) summarizing U.S. South Pacific albacore fisheries data collected

during the 1989-90 season. The season began in mid-November 1989, and continued through mid-April 1990. Thirty-eight U.S. jigboats participated in the fishery, the same number as during the 1988-89 season.

Samplers collected catch and fishing effort statistics from vessel logbooks, and measured fork lengths of individual fish from landed catches. Catch-and-effort sampling coverage increased from 43% for the 1988-89 season to 86% for the 1989-90 season. Length-frequency coverage increased from 68% in 1988-89 to 80% in 1989-90.

Catches were highest in January 1990 (roughly 1,200 miles east of New Zealand) and in March 1990 (roughly 2,100 miles east of New Zealand). The total catch for the 1989-90 season continued an upward trend for the U.S. fishery, reaching 3,882 metric tons (t) (Figure 1), a 5% increase from the 1988-89 total catch of 3,700 t. The catch per day fished (CPUE) for the U.S. South Pacific albacore fleet increased 17% from 236 in 1988-89 to 275 in 1989-90. The highest CPUE, an average of 291 fish/day, occurred in March approximately 2,100 miles east of New Zealand.

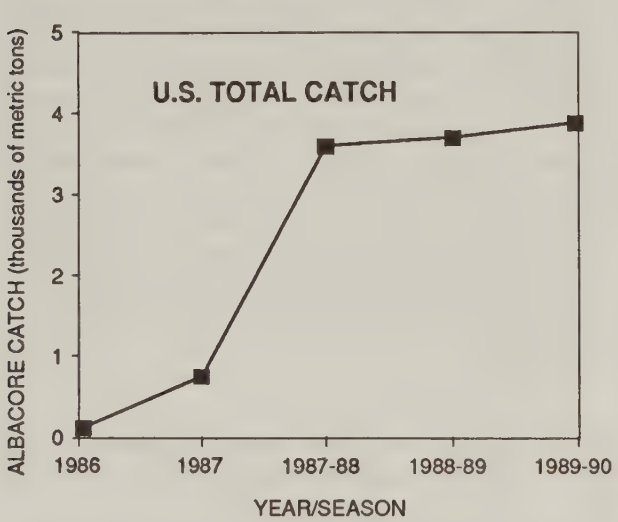

Figure 1. U.S. albacore catch (metric tons) in the South Pacific by year/season.

Over 67,000 albacore were measured for fork length (tip of snout to fork of the tail) from U.S. landings in American Samoa, and from catches on board New Zealand jigboats, during the 1989-90 season. Overall, the average size of albacore decreased for the third straight season, from 68.9 cm (15.0 lbs) in 1988-89 to 67.4 cm (14.0 lbs) in 1989-90. Fish sizes ranged from 41 to 108 cm fork length, and showed a tri-modal distribution (Figure 2).

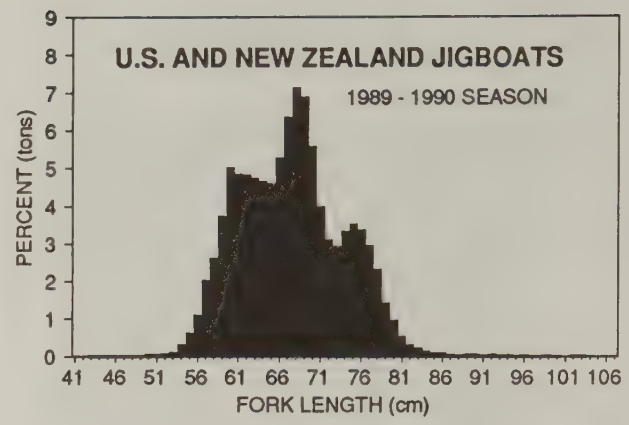

Figure 2. Length-frequency of South Pacific albacore caught by U.S. and New Zealand jigboats during the 1989-90 season.

(G. Rensink, FTS 893-7192)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Albacore Drift Gillnet Interaction Project

Greg Yee and Gary Rensink departed Honolulu aboard U.S. albacore troll vessels in June. Their goal is to observe the daily catch of albacore for evidence of injuries caused by encountering high-seas drift gillnets in the North Pacific. This is the second year of observations in support of the SWFSC's albacore gillnet project as well as the larger NMFS initiative on North Pacific driftnet research.

In another phase of the project, Dave Holts and Cheryl Brown are preparing for the *Townsend Cromwell* cruise in August 1991. The *Cromwell* will operate in the North Pacific Transition Zone where a drift gillnet (4 km in length) will be deployed to sample the epipelagic waters. The goal is to quantify high seas gillnet catches, and investigate delayed mortality of albacore due to gillnet encounters. The make up and quantity of the albacore catch will be documented. Both surface and underwater observations of albacore entanglement, escapement, and dropout prior to landing will be made. Albacore dislodged from the net as it is hauled, before and after the net breaks the surface, will be documented. At five stations, underwater visual and video observations will be recorded to enumerate catch loss. This will include tagging a known number of albacore in the net and recording the number retrieved onboard after net hauling. (D. Holts, FTS 893-7186)

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

Estimation of Fishery Parameters from Tag Recapture Data

In previous issues of the Bimonthly Report of Activities of the Southwest Fisheries Science Center, Operations Research Analyst Carlos Salvadó and Fishery Biologist Pierre Kleiber reported progress in the development of a method of analyzing fisheries from tag-recapture data by the use of point source solutions, or Green's functions, of the field equations that represent the tag and stock dynamics. Recent results of the study indicate that the stock parameters can be estimated simply by considering the moments of the Green's functions.

In the Green's function approach to modeling tag dynamics,

$$g_0(\mathbf{r}, t|\mathbf{r}_0, t_0) = \frac{c^T(\mathbf{r}, t)}{\#_T F}$$

is the effort dependent probability density of finding a tag at location r at time t if at an earlier time t_0 it was at r_0, $c^T(r,t)$ is the tag catch rate density, $F=qe$ is the fishing mortality rate, and $\#_T$ is the number of tags released at (r_0,t_0). The effort independent probability density $g(r,t \mid r_0,t_0)$ of finding a tag at location r at time t, if at an earlier time t_0 it was at r_0, can be computed from

$$g(\mathbf{r}, t|\mathbf{r}_0, t_0) = g_0(\mathbf{r}, t|\mathbf{r}_0, t_0) + \\ +(\frac{1}{\#_T}) \int_{\mathcal{T}} dt' \int_{\mathcal{A}} dS' g(\mathbf{r}, t|\mathbf{r}', t') c^T(\mathbf{r}', t') \,,$$

where $\mathcal{A}$ is the area of the fishery and $\mathcal{T}$ is the time interval $[t_0,t]$. The following mathematical properties of g allows us to estimate the stock parameters:

(1) Normalization.

Initially, g is normalized:

$$\int_{\mathcal{A}} dS g(\mathbf{r}, t_0|\mathbf{r}_0, t_0) = 1 \,.$$

This allows evaluation of q, the catchability

(2) Nonconservation Of Probability.

Because there is a probability sink due to natural mortality, for $t>t_0$ probability is not conserved:

$$\int_{\mathcal{A}} dS g(\mathbf{r}, t|\mathbf{r}_0, t_0) = e^{-M(t-t_0)} \,,$$

where M is the natural mortality rate.

(3) Shape.

To discuss in the simplest of terms the shape of g we will assume that the tagged and untagged fish population is characterized correctly by a translationally invariant differential operator (i.e., a differential operator with constant coefficients) that includes advection with velocity V and diffusion with diffusivity K. The first moment of g for this case is given by

$$\int_{\mathcal{A}} dS \, \mathbf{r} \, g(\mathbf{r}, t|\mathbf{r}_0, t_0) = \\ e^{-M(t-t_0)} \left[\mathbf{r}_0 - \mathbf{V}(t - t_0)\right] \,,$$

and the second moment of g, by

$$\int_{\mathcal{A}} dS \, \mathbf{r}^2 \, g(\mathbf{r}, t|\mathbf{r}_0, t_0) = \\ e^{-M(t-t_0)} \left\{2K(t - t_0) + \left[\mathbf{r}_0 - \mathbf{V}(t - t_0)\right]^2\right\} \,.$$

The asymptotic properties of the time integrals of the moments yield expressions in terms of the fishery parameters. The zeroth moment asymptote is given by

$$\lim_{t\to\infty} \int_{\mathcal{T}} dt \int_{\mathcal{A}} dS g(\mathbf{r}, t|\mathbf{r}_0, t_0) = \frac{1}{M}$$

which allows us to estimate M; the first moment asymptote yields

$$\lim_{t\to\infty} \int_{\mathcal{T}} dt \int_{\mathcal{A}} dS \, \mathbf{r} g(\mathbf{r}, t|\mathbf{r}_0, t_0) = \frac{\mathbf{r}_0}{M} - \frac{\mathbf{V}}{M^2} \,,$$

which allows us to estimate V because we know $\mathbf{r}_0$ and M; and the second moment asymptote gives

$$\lim_{t\to\infty} \int_{\mathcal{T}} dt \int_{\mathcal{A}} dS \, \mathbf{r}^2 g(\mathbf{r}, t|\mathbf{r}_0, t_0) = \\ \frac{\mathbf{r}_0^2}{M} + \frac{2(K - \mathbf{r}_0 \cdot \mathbf{V})}{M^2} + \frac{2\mathbf{V}^2}{M^3}$$

which allows us to estimate K.

Tag-return data from the eastern tropical Atlantic skipjack fishery were used to test this estimation technique, resulting in q=6.28 10^{-6}, M=7.18 10^{-2}/mo, V=120 nm/mo and a diffusive velocity of 515 nm/mo. These estimates can now be used as points of departure for future iteration to determine the optimal fit to the observed data. (C. Salvadó, FTS 893-7052; P. Kleiber, FTS 893-7076)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Juvenile Rockfishes in Salmon Diet Evidence Unusual Features of 1991 Recruitment

Juvenile rockfishes, *Sebastes* spp., are the major prey of king salmon during May and June of their first year. This has been a finding of the Groundfish Communities Investigation, which has monitored this relationship since 1980. The current year has been unusual in several respects, however. Although typically rockfish young-of-the-year can be expected to appear in the diet from late April to mid-May, their first appearance this year was on June 2. Furthermore, they have been smaller and fewer than usual. The average size has been 41 mm standard length (SL), compared to 51 mm SL during 1990, and the numbers taken (an average of 1.03 per salmon, n=430) have been the lowest since 1986. Most striking has been their unusual species composition. The dominant prey species every year since 1980 has been the shortbelly rockfish, *Sebastes jordani*, which never constituted less that 60% of the individuals in the diet. Based on preliminary analysis of current samples, however, the dominant prey species this year has been the canary rockfish, *Sebastes pinniger*, which has constituted 32% of the diet. And this species has been followed by widow rockfish, *S. entomelas*, at 18%, and by the squarespot rockfish, *S. hopkinsi*, and the boccacio, *S. paucispinus*, both at 14%. Shortbellies have ranked fifth, at 10% of the prey individuals in the diet. (P. Adams, K. Silberberg, and T. Laidig, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATION

1991 Pelagic Juvenile Rockfish Survey Completed

In spite of adverse weather conditions, the annual May-June survey of pelagic juvenile rockfish was successfully completed for the ninth consecutive year. Since 1983 staff members of the Groundfish Analysis Investigation have studied the distribution and abundance of young-of-the-year rockfish (*Sebastes*) during cruises aboard the NOAA Ship *David Starr Jordan*. The survey region includes waters off central California between Monterey Bay and Point Reyes, out to distances well in excess of 25 miles. The primary objectives of the research are to estimate the year class strengths of commercially important rockfishes prior to their recruitment to the west coast groundfish fishery and to develop a better understanding of factors contributing to year class success or failure.

This year the cruise lasted 29 days, during which time the area was surveyed three times, with each sweep through the study area consisting of 36 stations. Over 6,000 young-of-the-year juvenile rockfish were captured in 157 nighttime midwater trawls. In contrast to most previous years, when abundance patterns have decreased with each successive sweep, this year catch rates increased dramatically. Total catches of pelagic juvenile rockfishes at the standard stations occupied during each sweep were 195, 654, and 3,721, respectively. The seasonal abundance pattern observed this year is similar to that seen in 1986, i.e., catches increasing with time and fish being comparatively smaller (15-45 mm SL) than normal (30-60 mm SL). As usual, shortbelly rockfish was the dominant species captured, although it did not constitute as high a percentage of the catch as in most previous years (Figure 1). Several species were more prevalent than normal, including canary, widow, yellowtail and brown rockfishes.

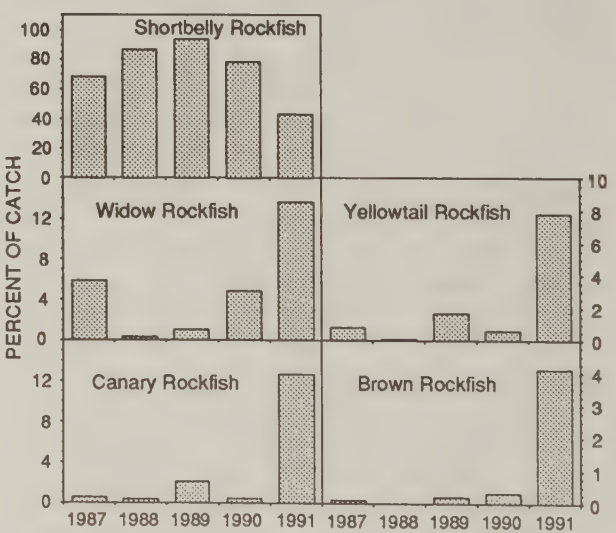

Figure 1. Percentage contribution of several species to the total catch of pelagic juvenile rockfish (1987-91).

Oceanographic conditions during the cruise had a major influence on this year's catches. The upwelling index for the month of May was the highest

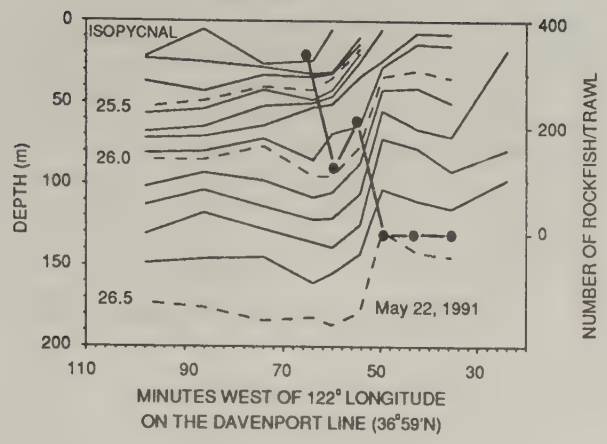

Figure 2. Upwelling front off Davenport, California, with juvenile rockfish catch rates superimposed upon water density patterns with depth and distance offshore 122 longitude.

recorded since 1981. During the first sweep, this seemed to result in advection of the postlarvae and juveniles by Ekman transport to the western boundary of our survey area. Upon completion of the first sweep, trawls were conducted in an area extending seaward of the terminal Davenport station. As the vessel proceeded to the west, a frontal zone was encountered between recently upwelled water (cold, high salinity) lying nearshore and the warmer, lower salinity oceanic water that had been displaced seaward. Dramatic differences were observed in the catch of juvenile rockfishes on either side of this front (Figure 2). During the second and third sweeps, there was a relaxation in wind speeds and upwelling, and as nearshore temperatures increased, so did the catch of juvenile rockfish. (D. Woodbury, FTS 556-0565)

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Catch and Effort Study at Cordell Bank, California

From June 1986 to April 1991, chartered cruises were made at approximate monthly intervals to the Cordell Bank seamount off northern California. The principle purpose of these cruises was to collect yellowtail rockfish (*Sebastes flavidus*) to assess their physiological conditions and reproductive states. Although we targeted our efforts on yellowtail rockfish, the hook-and-line fishing methods resulted in the landing of a variety of species that co-locate in these rocky bottom, mid-water habitats. Data were compiled on all fish landed, their identification by species and the numbers caught, the number of fishermen, and the time spent actively fishing.

A total of 45 trips was completed with 7,285 fish caught, comprised of 26 finfish species and one octopus. During the 5-year study, years 1987 and 1990 had 12 continuous monthly collections while years 1989 and 1991 had 4 and 3 collections, respectively. The distribution of trips was fairly even among the 12 months. Total catches and the mean catch (number of fish/trip) varied among and between months. The highest catches occurred during December and the lowest during November, while the catch rates (CPUEs) showed a different pattern of high rates in February and low rates in October. Interannual differences in catches were also observed. Total catches reflected the total number of trips made, but the more directly comparable mean catch per trip values showed that 1990 was the most productive year, while 1987 was the least productive. The same pattern was also seen in CPUEs.

Over the 6-year study, 26 fish species were caught. Temporal distribution of species was consistent on both the monthly and yearly scales (Tables 1 and 2), ranging 13-19 species per month and 15-17 per year. The most abundant species collected was our target species, yellowtail rockfish, which made up 47.9% of the total catch. The succeeding four species, combined with the yellowtail rockfish, comprised over 80% of all fish landed (*S. rosaceous, S. paucispinis, S. serranoides, S. chlorostictus*). Of the 13 most abundant species, all but one (*Ophiodon elongatus*) were *Sebastes* species. There was no particular seasonal pattern to landings of the above five abundant species. All were captured throughout the year, suggesting year-round residency. *S. ruberrimus* and *S. ovalis* were also caught during all months, though less abundant. Other species, *S. entomelas, S. goodei*, and *S. mystinus*, occurred in high incidence restricted to short time periods (i.e., July, March and September, and May, respectively).

Further analyses of these data are planned, with related party boat landing data being collected for comparison. During September 1991, we plan to again collect hook-and-line fish at Cordell Bank and to determine the extent to which this sampling method represents the fish community by utilizing a video- equipped remote underwater vehicle.

Table 1. Catch and effort data by month for Cordell Bank hook-and-line charters, 1986-1991, all species combined.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of Trips	4	4	4	4	2	3	4	4	4	3	3	6
Total Catch	844	563	719	640	330	498	739	640	636	514	363	799
$\bar{x}$ Catch/Trip	211	141	180	160	165	166	185	160	159	171	121	133
No. of Species	14	13	14	19	13	16	17	15	16	14	15	17
$\bar{x}$ No. of Spp./Trip	10.5	8.5	11.5	10.8	9.0	10.7	12.3	11.1	9.3	8.67	9.3	11.3
CPUE	4.893	6.803	4.173	3.415	4.010	6.070	5.323	3.785	4.805	3.100	3.857	3.327

Table 2. Catch and effort data for Cordell Bank hook-and-line study, 1986-1991, all species combined.

	1986	1987	1988	1989	1990	1991	ALL
No. of Trips	7	12	7	4	12	3	45
Total Catch	899	1434	899	700	2890	473	7285
$\bar{x}$ Catch/Trip	127	120	128	175	241	158	162
No. of Species	18	18	17	15	19	16	26
$\bar{x}$ No. of Spp./Trip	10.7	9.2	9.4	10.0	10.5	10.3	10.0
CPUE	2.513	2.403	2.741	4.853	8.087	5.923	4.441

(M. Eldridge, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

Progress Being Made on Administrative Information Management System Project

An integrated administrative information system has been under development to meet the expressed needs of the SWR/SWFSC potential users in managing their resources effectively and efficiently. One of the primary objectives of the Administrative Information Management System (AIMS) is to supply the managers with timely and credible administrative information. The system would provide on-line entry and validation of administrative data into a master data base, provide programs to generate user-defined management reports, and provide access to read-only information for users manipulation.

Based on the analysis of the functional requirements submitted by the managers and potential users in response to the survey questionnaire, a conceptual design was formulated. The design was presented in the October 1990 Design Overview Report. An amendment, which documented the users recommendations and the rationale for the inclusion and exclusion of the recommendations in the design concept, was submitted in December.

Upon approval of the overview report, the AIMS Master Design Plan was developed. Originally the Master Design Plan would be an options report presenting the cost/benefit analysis of implementing AIMS on the Center's existing and two or more alternate hardware-software platforms. Due to the severe budget climate, no funds would be appropriated for procurement of new platforms. Based on this constraint, Dr. Barrett approved ITS's recommendation to drop the option report and directed ITS to focus their efforts in configuring a system based on current resources.

The AIMS Master Design Plan was completed in June. The system design is based on an open-ended system. It is structured to allow phased implementation of information modules on a priority schedule, the implementation of information categories within modules, the addition of approved information categories not now identified, and the upgrade to and integration with compatible hardware and software. The plan has been submitted to the managers and potential users for their review, their comments, and in reference to their needs, their priority levels for implementation.

By consensus the managers will determine the inclusion or exclusion of the reporting sets within each information module and the priority levels for implementation. The Plan will be amended to document the comments of the reviewers and the priority levels set by the decision managers for implementation. The Amended AIMS Master Design Plan will serve as the planning document for a phased implementation of an on-line integrated management system. (D. Roll, FTS 893-7057)

PUBLICATIONS

Published

Clarke, R. P., and S. S. Yoshimoto. 1990. Application of the Leslie model to commercial catch and effort of the slipper lobster, *Scyllarides squammosus*, fishery in the Northwestern Hawaiian Islands. Mar. Fish. Rev. 52(2):1-7.

Commercial catch and effort data were fit to the Leslie model to estimate preexploitation abundance and the catchability coefficient of slipper lobster, *Scyllarides squammosus*, in the Northwestern Hawaiian Islands (NWHI). A single vessel fished for 34 consecutive days in the vicinity of Laysan Island and caught 126,127 total slipper lobster in 36,170 trap-hauls. Adjusted catch of legal slipper lobster dropped from a high of 3.70 to 1.16 lobster per trap-haul. Preexploitation abundance at Laysan Island was an estimated 204,000 legal slipper lobster, which was extrapolated to yield an estimate of $1.2 * 10^6$ to $3.8 * 10^6$ lobster for the entire NWHI slipper lobster fishery.

Duffield, D. A., J. Chamberlin-Lea, J. C. Sweeney, D. K. Odell, E. D. Asper, and W. G. Gilmartin. 1991. Use of corneal cell culture for R-band chromosome studies on stranded cetaceans. *In:* J. E. Reynolds and D. K. Odell (eds.), Marine mammal strandings in the United States, p. 91-100. Proceedings of the Second Marine Mammal Stranding Workshop, Miami, Florida, December 3-5, 1987.

The prolonged viability and uncontaminated nature of corneal cells in the intact eye make the cornea a reliable source of cultured cells from post-mortem animals. From corneal cell cultures, a fluorescent R-band staining technique was used to look at heteromorphic (variable) regions in the karyotypes of five cetacean species which strand on United States coastlines (*Feresa attenuata, Pseudorca crassidens, Globicephala macrorhynchus, Kogia breviceps*, and *Megaptera novaeangliae*). All of these species had numerous heteromorphic R-band regions in their chromosomes with variants which differed in size and intensity. The distribution of heteromorphic regions in these karyotypes was compared with *Tursiops truncatus*. In *M. novaeangliae* and *T. truncatus*, extra "marker" chromosomes were noted in the karyotypes of a few individuals. The results suggest that R-band chromosome heteromorphisms, as well as the extra chromosomes, are cytogenetic markers which can be used in populations studies to assess parentage and to look at regional population differences.

Approved by Science and Research Director, SWR

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